Goddard 3D Chemistry/Transport Modeling for CR-AVE

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Abstract and Introduction

The Goddard 3D chemistry and transport model (CTM) was run for Costa Rica-AVE to provide forecast and analysis fields of aerosol, CO, and CO2 for mission planning support. CTM forecasts were used to help locate regions of particular air mass characteristic, e.g., conditions representative of convective transport, tropical versus mid latitude origin, biomass burning influence, etc. The secondary objective was to provide global chemical and aerosol perspective to aid in interpreting aircraft and satellite observations and comparisons. Comparison of model CO and CO_2 output with WB-57 in situ data shows that in general the model produces mean mixing ratios and vertical and horizontal gradients similar to observed. Comparison with early (v. 1) MLS CO data shows that the model and MLS contain similar patterns of high and low CO in the upper troposphere along latitude gradients produced by sources and convective uplifting, but display the known MLS high bias increasing down to about 300 mbar. A preliminary sample of reprocessed data (v 2.1) for MLS CO shows improvement in comparison with the model and WB-57 data, but bias remains below about 150 mbar.

TRANSPORT MODEL AND FLUXES

Chemistry/Transport Model (CTM) Description

- Meteorological fields from the Goddard Global Modeling and Assimilation Office (GMAO) GEOS-4 system.
- Aerosol process model derived from the Goddard Chemistry Aerosol Radiation and Transport (GOCART)
- CO_2 and CO processes from the Goddard PCTM and Harvard GEOS-CHEM.
- Chemical and aerosol processes calculated “on line” in the assimilation model. Operationally, on-line is more efficient and should in principal be more accurate.
- Resolution: 1° x 1.25° x 55 vertical layers, time step 30 min.

Direct CO emissions: fossil fuel, biofuel, and biomass burning. The direct emissions input at the surface layer also include CO oxidized from natural and anthropogenic NMHC calculated using scaling factors summarized from the literature. Atmospheric CO chemical production from CH_4 oxidation accounts for about 1/3 of the total CO source. The chemistry uses prescribed OH, H2O2, and NO3 fields from GEOS-CHEM for CO and gaseous sulfur oxidation. Biomass burning emissions of CO_2, CO, SO_2, BC and OC are based on the burned biomass inventory, estimated from near-real-time Terra and Aqua MODIS fire counts.

For CO and CO_2, regional tracers from sources in North America, South America, and Africa were carried in addition to the global total.

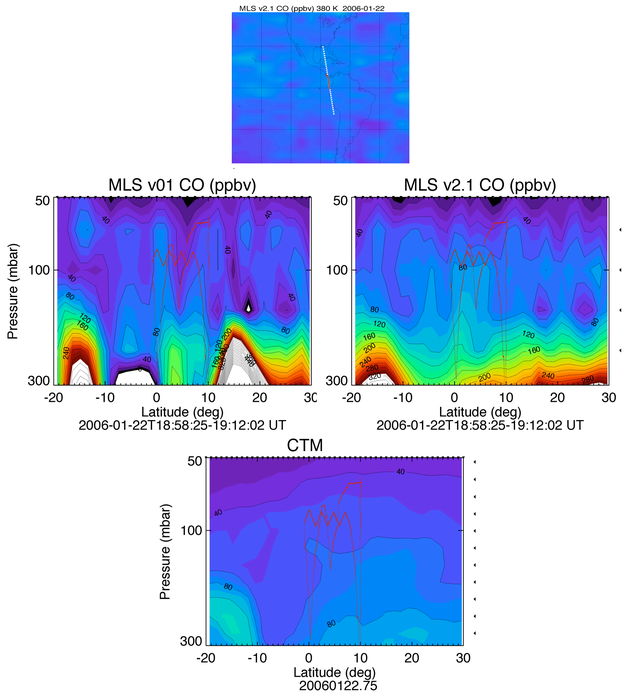
GOCART modules include emissions for SO_2 and dimethyl sulfide to form sulfate particles, dust, black carbon (BC), organic carbon (OC), and sea-salt emissions from industrial, biomass burning, deserts, ocean, and biogenic sources.

Model analysis and forecast plots at selected vertical levels and cross-sections in the flight vicinity are accessible via a web site:

http://code916.gsfc.nasa.gov/People/Colarco/CRAVE/

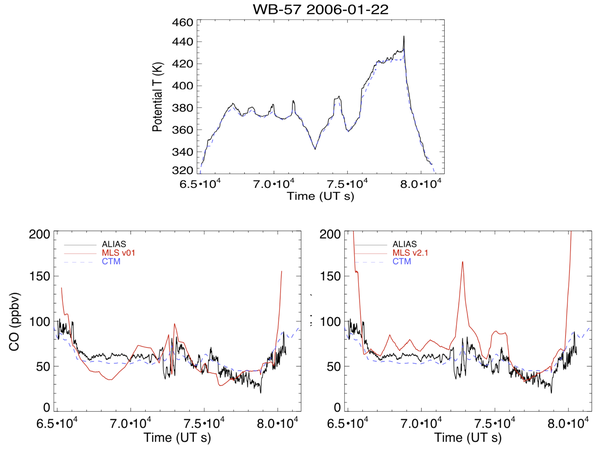
MLS v2.1 CO FIRST LOOK

Model-Data Cross-section Comparison



Cross-sections sampled along a portion of MLS track (upper panel) show somewhat similar gradients in upper troposphere and lower stratosphere between model and observations, but MLS data have much higher mixing ratios below about 100 mbar. Preliminary MLS version 2.1 is more like model than previous version 1.

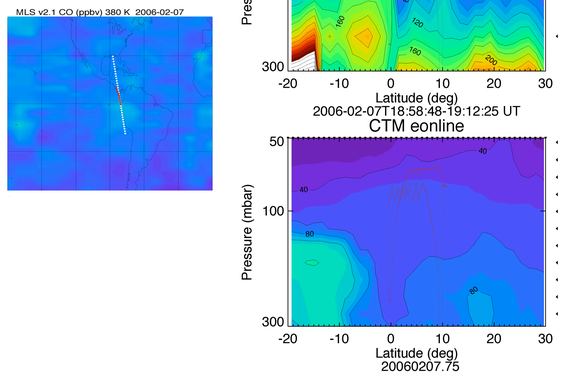
WB-57 In Situ Data Comparison



MLS and model interpolated to WB-57 flight track show generally good correspondence at upper flight altitudes (higher potential temperature), but MLS is too high in mixing ratio at ascent and descent altitudes. Preliminary v2.1 follows aircraft altitude changes much better.

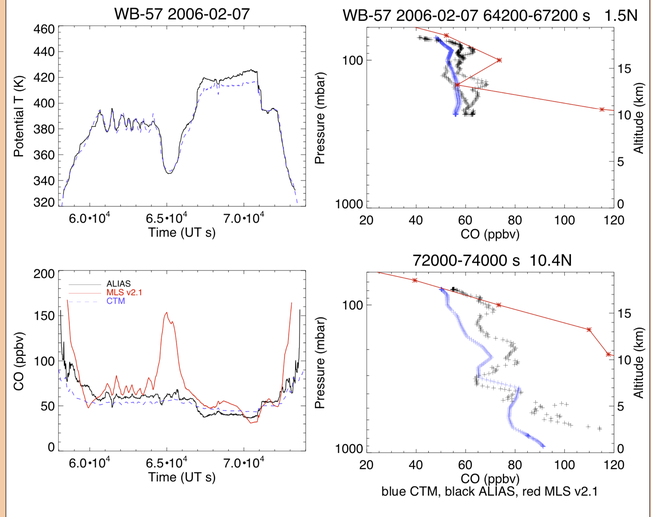
ANOTHER CO CASE STUDY

Cross-section Comparison II



General cross-section comparison with model for Feb 7, 2006 is similar to that for Jan 22 (at left) although synoptic situation is rather different. Again, preliminary MLS v 2.1 is significantly better than v1 (not shown).

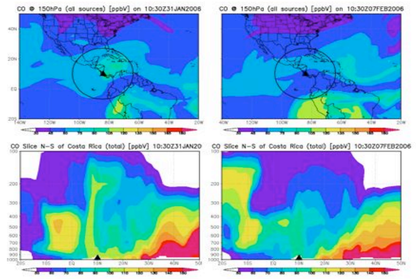
Flight Track and Profile Comparisons



Comparison to in situ data along flight track is similar to Jan 22 (at left). Nearest profile comparisons from middle and end of flight show MLS (v2.1) still too high in mixing ratio below about 100 mbar.

CHEMICAL FORECASTS

Flight Planning Examples



Chemistry/transport model 2-day forecasts of CO mixing ratio for 2006-01-31 and 2006-02-07 on the 150 hPa pressure surface and a latitude slice through Costa Rica show how forecasts for the CR-AVE flight region varied. In the forecast for 2006-01-31, oceanic convection in the region south of Costa Rica lifts high CO mixing ratios from near the surface to the upper troposphere in the region of San Jose. Convection over South America is suppressed. In the forecast for 2006-02-07, the flight region is strongly influenced by advection of low CO air from the southern hemisphere, eastern Pacific. Further south, the upper troposphere is affected by air lifted to the UT in convection over South America and advected westward over the Pacific. These different meteorological regimes produce very different forecast UT tracer fields in range of the aircraft.

Toward Science-Level Validation

CTM forecasts were used to help locate regions of particular air mass characteristic for flight planning purposes. Much about proposed flight conditions can be learned through purely meteorological analysis, but in many cases the correlation between meteorology and aerosol/constituent abundances is not unique. In these situations, chemistry transport models enhance our ability to characterize validation opportunities and satisfy validation priorities.

CTM analyses are used in comparison to aircraft and satellite to help understand mission data in terms of constituent gradients and temporal changes caused by chemical and transport processes in the troposphere and stratosphere. Model comparisons with flight data provide a connection to MLS observations at nearby, but non-coincident longitudes. As these models are representations of our understanding of atmospheric processes, this analysis is an important step to “science-level validation”: the determination of whether a given data set is sufficient to quantitatively constrain hypotheses regarding our fundamental understanding. Analysis is ongoing.

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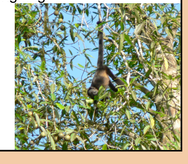

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Photography courtesy of Mike Kurylo.

NASA Aura Validation Project